63-3-4

TM-(L)-734/037/00

TECHNICAL MEMORANDUM

(TM Series)

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1604 Simulation Program Descriptions

Milestone 11

Tracking Data Paper Tape Generation Routine (SRADTPE)

by

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15 March 1963

Approved

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1.0 IDENTIFICATION

1.1 Title

Tracking Data Paper Tape Generation Routine (SRADTPE)
Ident: K12, Mod. 02

1.2 Programmed

February 1963, P. T. Kastama, System Development Corporation
D. Lee, Lockheed Missiles and Space Company*

1.3 Documented

March 1963, P. T. Kastama, System Development Corporation

2.0 PURPOSE

This program is intended to provide a simulation capability, which will produce tracking data on paper tape for unaugmented tracking stations. This data is intended to represent the actual data generated by various antennas during vehicle pass-over for a given station, vehicle, and revolution number. The antennas for which data will be produced are: VERLORT, TLM18, DOPPLER (400 mc), SHIP MODII (AN/SPQ-2), SHIP TLM18, and SHIP PMR DOPPLER.

3.0 USAGE

3.1 Calling Sequence

L	RTJ	SRADTPE
L+1	NORMAL RETURN	
L+2	ZRØ	0
	ZRØ	Vehicle Number
L+3	ZRØ	0
	ZRØ	Delta T

*Part of the program "PREDICT" was extracted to complete the paper tape output from SRADTPE.

L+4	Antenna Name....Left justified, with trailing blanks.	
	20.....20	
L+5	ZRØ	0
	ZRØ	Revolution Number
L+6	ZRØ	0
	ZRØ	Reset Tape Unit Number
L+7	ZRØ	0
	ZRØ	Station Number
L+8	ZRØ	0
	ZRØ	Print Option (1=Print)

3.2 Operating Procedures

SRADTPE may be called upon in two different ways. One way utilizes the standard COP function card, while the second method is to use the SIPSA system and control deck. Both card formats are described in Section 3.7.

3.3 Input Parameters

Several input parameters, in addition to a Reset Tape, are necessary to generate tracking data. These parameters are defined as follows:

a. Vehicle Number

This number can be any number. However, it must compare with the vehicle number on the Reset Tape.

b. Time Increment

The data punched on paper tape are usually spaced at four-second intervals (excluding the Doppler antennas, whose data are spaced at two-second intervals). However, if a different time increment is desired, the user has an option to specify a value.

c. Antenna Name

Antenna type must be specified in order that the appropriate format and output can be simulated.

d. Revolution Number

This number specifies the particular revolution for which data is desired.

e. Reset Tape Unit Number

This number indicates which tape unit should be read for the Reset Tape.

f. Station Number

This number must define any legal unaugmented station for which the station coordinates are available in the Reference Pool.

g. Off-Line Data Printout Option

The program will provide an optional off-line listable BCD dump for every point generated. The off-line data dump consists of TAU (Machine time); System time; the X,Y,Z,$\dot{X}$,$\dot{Y}$,$\dot{Z}$ inertial vector; local antenna position; and the polar elements. The data will be on Tape 3 in BCD listable format. This off-line data printout option is provided to minimize 1604 computer run time.

3.4 On-Line Messages and Printouts

a. PLEASE READY PAPER TAPE PUNCH FOR 5 LEVEL TAPE. I WILL REQUIRE APPROXIMATELY XXX FEET OF UNUSED PAPER TAPE TO COMPLETE THE RUN. WHEN PUNCH IS READY PRESS START TO CONTINUE.

This printout indicates to the operator that paper tape is about to be punched. XXX is a decimal number computed by the program as a function of duration to indicate about how much paper tape will be needed.

b. ALL TRACKING DATA HAS BEEN PUNCHED ON PAPER TAPE. PRESS START TO RETURN TO CONTROL PROGRAM.

When all data for each function request card has been punched on a paper tape, the above on-line printout will be provided.

3.5 Error Printouts

a. NO ANTENNA OR WRONG ANTENNA SPECIFIED. CORRECT FUNCTION CARD AND PRESS START TO RETURN TO CONTROL PROGRAM.

Illegal antenna name on function card. Correct card, load deck in reader, and press start to return to control program, which will re-read the deck.

b. STATION OR REV NUMBER NOT IN ACQUISITION TABLE. CORRECT FUNCTION CARD AND PRESS START TO RETURN TO CONTROL PROGRAM.

Information in Acquisition Table is not available for given revolution and station numbers. Correct the function card, load deck in reader, and press start to return to control program to re-read the deck.

c. LATITUDE AND LONGITUDE ARE NOT AVAILABLE FOR THIS STATION. PRESS START TO RETURN TO CONTROL PROGRAM.

Change function card to request data for a different station or insert latitude, longitude, and height in the particular station cells in SLAT, SLONG, and SH in the Reference Pool.

3.6 Tape Assignments

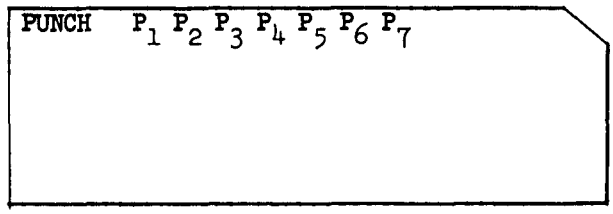
Tape 1 must contain the 1604 Augmentation System Utility Master.

Tape 3 will contain a listable BCD dump of every data point upon completion of SRADTPE, if requested.

The Reset Tape may be placed on Tape Unit 2, or 4-12, as long as the unit number is specified on the function card.

3.7 Control Card Formats

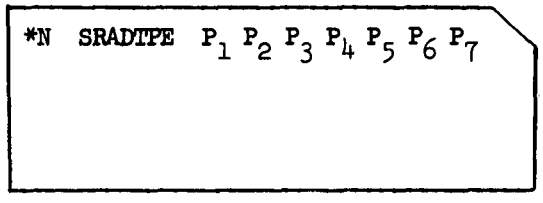
3.7.1 The Tracking Data Paper Tape Punch Request Card (PUNCH).



Columns	Content	Meaning
1-8	PUNCH	Name of request, left justified with trailing blanks.
9-13	P_1	Vehicle number, right justified (decimal integer $\leq$ 99999).
15-16	P_2	Δt in seconds (blank if not required), right justified (decimal integer $\leq$ 99 seconds).
18-21	P_3	Antenna name in BCD, left justified with trailing blanks. Choices are: VELT (Verlort) TL18 (TLM18) DOPR (Doppler) ANQ2 (AN/SPQ-2) SHIP (Ship TLM18) SPMR (Ship PMR Doppler)
23-26	P_4	Revolution number, right justified (decimal integer $\leq$ 9999).
28-29	P_5	Reset Tape Unit number, right justified, unit=2, 4-12.
31-32	P_6	Station number, right justified (must be unaugmented station number).
34	P_7	List option. If P_7=1, data will be written on Logical Tape Unit 3 to be listed after the run is complete.

In addition to the PUNCH card, certain system control cards are necessary to operate SRADTPE with the SIPSA system. (See Operating Instructions, Milestone 7, TM-(L)-734/022/00).

3.7.2 The MTCII Function Request Card Format



where:

* Identifies the card as a function request, and must be in Column 1.

N is an optional decimal integer specifying a logical equipment unit on which a storage analysis is to be output.

P_1,P_2,P_3,P_4,P_5,P_6,P_7 are the same input parameters described in Section 3.7.1. From these parameters, MTCII generates the calling sequence described in Section 3.1.

3.8 Jump Key Settings

There is one jump key setting involved in the operation of SRADTPE. If it is desired to use an old format (pre-augmentation) Reset Tape, it is necessary to set Jump Key 3 on the 1604 console. If a new format (augmentation) Reset Tape is used, no jump key settings are necessary.

3.9 Output Data Formats

See SIPSA Operating Instructions, Milestone 7, TM-(L)-734/022/00 for Paper Tape formats and a sample output listing.

4.0 METHOD

4.1 Tracking Data Generation

The method employed to generate tracking data is to utilize the information from a Reset Tape (which contains a filled Breakwell Matrix and a filled Station Acquisition Table) to calculate the rise and set vectors ($T, X, Y, Z, \dot{X}, \dot{Y}, \dot{Z}$), and duration of a pass over a tracking station by the Breakwell Closed-Form Equations. Then, using the rise vector as the initial condition, the Satellite inertial position at a specified time increment (Δt) can be calculated by the Runge-Kutta advance integration method. By converting these inertial positions into the appropriate station local polar coordinates, the result can be formatted, and scaled to represent various antennas, and used as input data for checkout of operational tracking programs. In addition, System Time will be calculated and updated from the initial condition. Polar coordinates for the antennas consist of azimuth, elevation, and slant range. During conversion, an inverse-refraction correction is added onto the elevation for all antennas. (See Appendix A for a flow diagram of SRADTPE.)

4.2 Angular Noise Error

In order to produce meaningful simulated tracking data, antenna noise error is added to all the simulated data. The method employed is to define the maximum elevation error as δel. Then a random number N is generated ranging from -1 to +1. Thus the elevation error at any time, t_i, is δel N_i. The maximum azimuth error is defined as δaz/cos (elevation). For simulation purposes, δel and δaz are set equal to 0.003 radians.

5.0 RESTRICTIONS

5.1 Hardware Components

A 1604 Computer, card reader, paper tape punch, printer, and three tape units are required.

5.2 Subroutines Required

ATAN1	FIX	OUTPUT	SIMRESET
COS	FLOAT	PTR	SIN
COTRANS	FLOATBIN	RTP	SUBERR
SDIFEQ	MACGUT	SACQTIME	TAN
DIGITS	OUTERR	SETUP	TTE

5.3 RIPOOL Items Set and/or Used

AMPM	GAMMA	OMEGA	TAU
AZM	HRS	RA	VEL
CLOCK	JAE2	RAD	X
COMMON	LAT	REV	XD
DAY	LONG	SBCD	Y
DT	MIN	SEC	YD
FORCE	MONTH	SNO	Z
FORMAT	MU	ST	ZD

5.4 Other Restrictions

5.4.1 A Reset Tape must be specified and provided.

5.4.2 Jump Key 3 must be set if the Reset Tape is of pre-augmentation format.

5.4.3 Data punched is for unaugmented stations only. A paper tape for the augmented Indian Ocean Station will be punched in SRGR. (See TM-(L)-734/023/00, Milestone 11, for SRGR.)

6.0 TIMING

The operating time for SRADTPE is variable. The amount of time depends on the amount and type of data and duration of a pass. If an off-line listable output is requested, more time is required. For the test vehicle, an average run took 10 to 15 minutes not including set up time.

7.0 STORAGE REQUIREMENTS

	Decimal	Octal
Main Program	833	1501
Tables and Constants	168	250
Total Storage Requirement	1001	1751

8.0 VALIDATION TEST

Since most of the subroutines used by SRADTPE are routines written by LMSC and have either been previously validated or operationally proven, mathematical validation of the tracking data is unnecessary. The validation tests on SRADTPE have been oriented mainly towards the reasonableness of the output.

8.1 Description of Input Parameters

The validation test of SRADTPE has been divided into two parts. The first part involved the request of tracking data from all radar antennas from many tracking stations. The data generated was then examined for reasonableness and output format. The second part involved the generation of radar data for a few revolutions and selectively comparing the output results against the ephemeris (for the identical revolutions) generated by the function "EPHFUN", using the same Reset Tape.

8.1.1 First Part

Several runs were made for all types of antenna data. Data was punched on paper tapes for antennas TLM18, DOPPLER, AN/SPQ-2, SHIP-TLM18, VERLORT, and the SHIP-PMR-DOPPLER. The data punched on paper tapes was then read in through the paper tape reader by the PT program. The output of the PT program was a readable printout of the paper tape, which was later examined for reasonableness and format.

8.1.2 Second Part

Using the identical Reset Tape, the "EPHFUN" function was used to

generate an ephemeris, using the Breakwell Closed-Form method, for the same revolution. Then the result was compared, selectively, against the data generated by SRADTPE for accuracy.

8.1.3 Hardware Configuration Control

a. Input Control Cards: Card Reader

b. Augmentation System Utility Master Tape: Tape Unit No. 1

c. Scratch Tape (Utility and Simulation): Tape Unit No. 3

d. Reset Tape (Simulation): Tape Unit 5

8.1.4 Input Control Cards

The following control cards were used for the validation tests:

a. *SIPSA (SIPSA system calling card)
b. START (Initialization request card)
c. PUNCH (Radar tracking data request card)

(See Appendix B for a listing of validation deck.)

8.1.5 Running Procedure

a. Input Control Cards placed in the card reader.
b. Tape Units 1, 3, 5 ready.
c. Read cards in and execute.

8.2 Expected Output from Test

a. On-line printout indicating all cards were read in.

b. Off-line BCD listing of every point generated.

c. On-line printout to indicate paper tape should be ready.

d. On-line printout to indicate data for one pass has been punched on paper tape.

e. Data from the paper tape printout should match very closely with the data from the "EPHFUN" function.

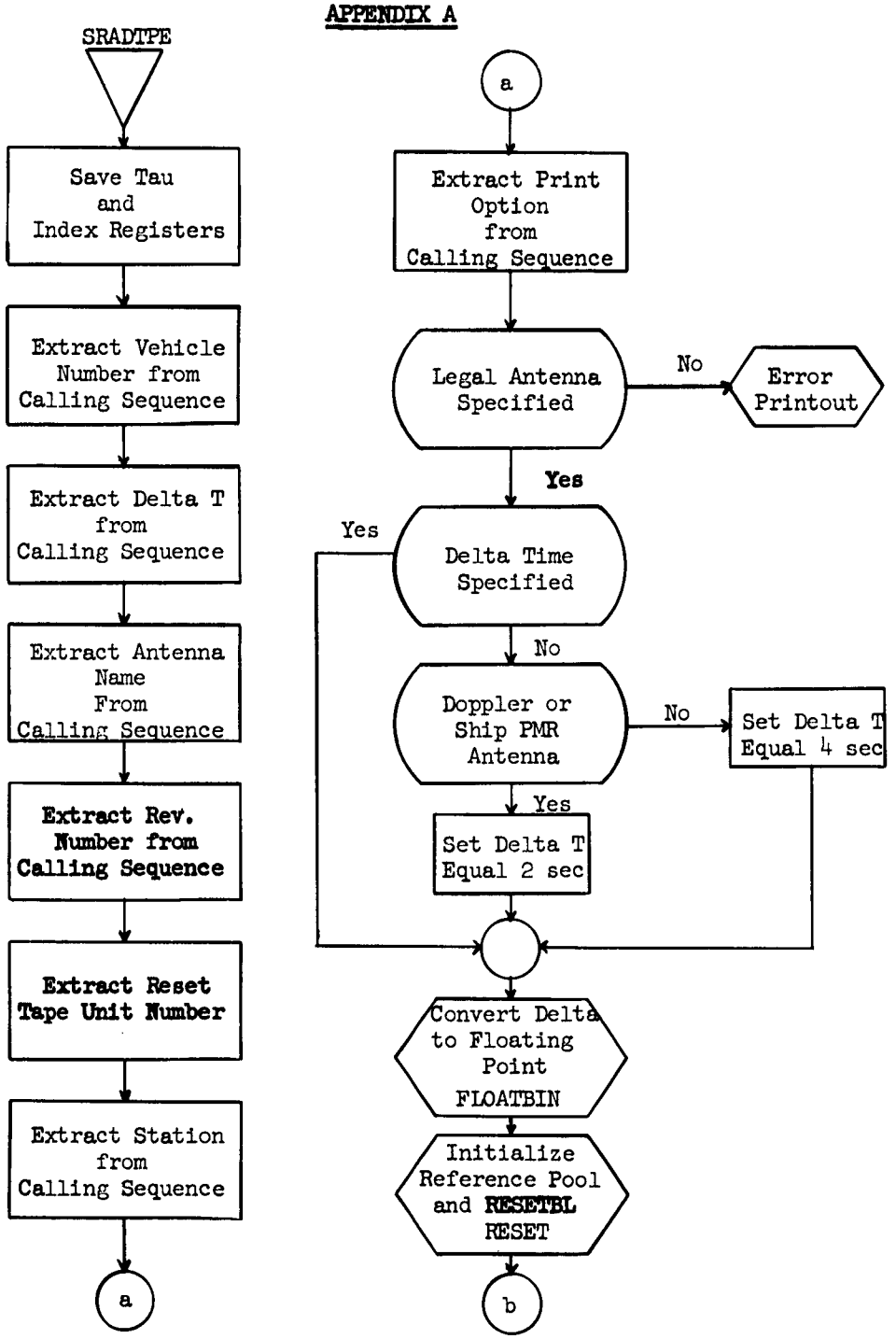
9.0 REFERENCES

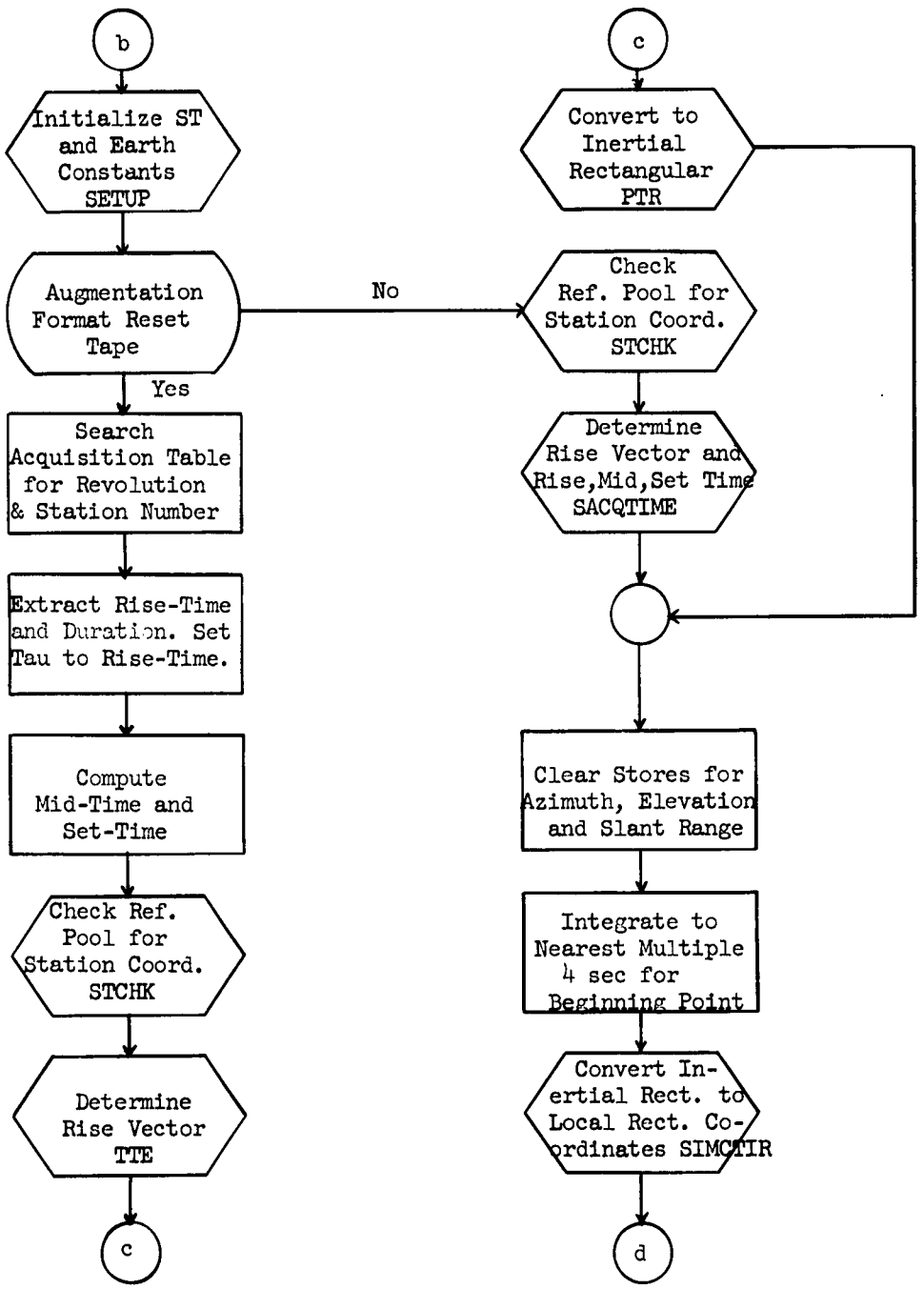
9.1 TM-(L)-734/015/00, Computer Program Design Specifications for the Simulation of the Augmented SCF Environment at the STA and CPDC (Milestone 4), System Development Corporation, 20 November 1962.

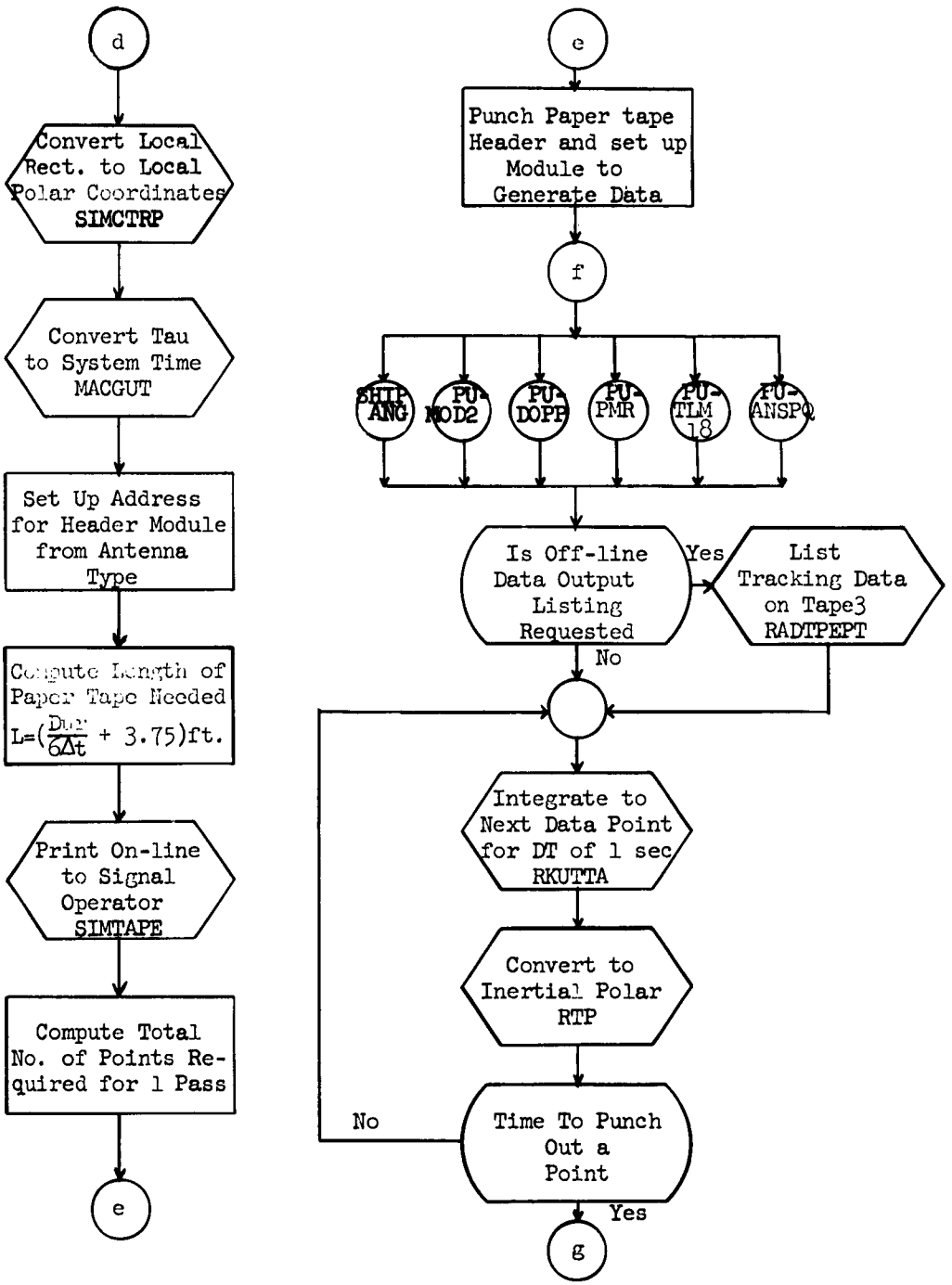
9.2 TM-(L)-734/022/00, Computer Operating Instructions for the Simulated Input Preparation System for the Augmented SCF Environment at the STA and CPDC (SIPSA), Milestone 7, System Development Corporation, 1 February 1963.

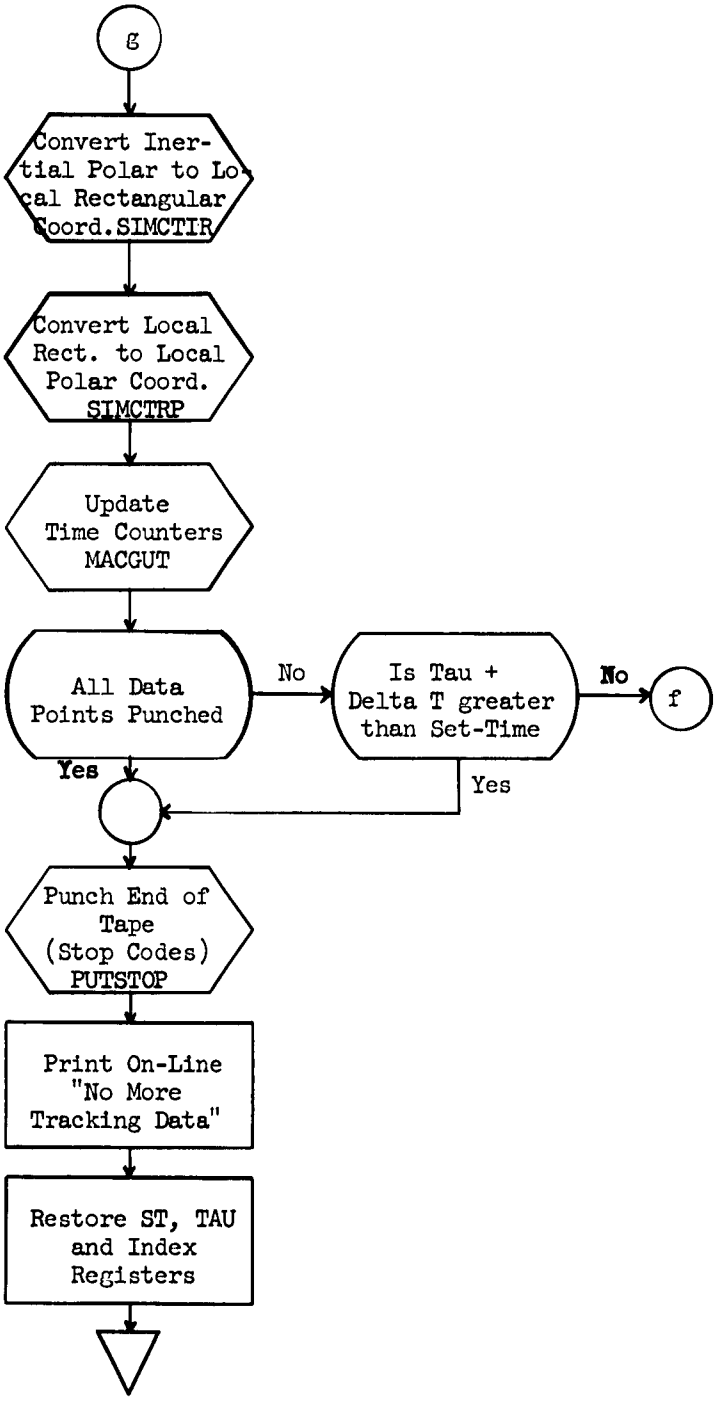
9.3 LMSD-447578, 1604 System Manual, Lockheed Missiles and Space Company.

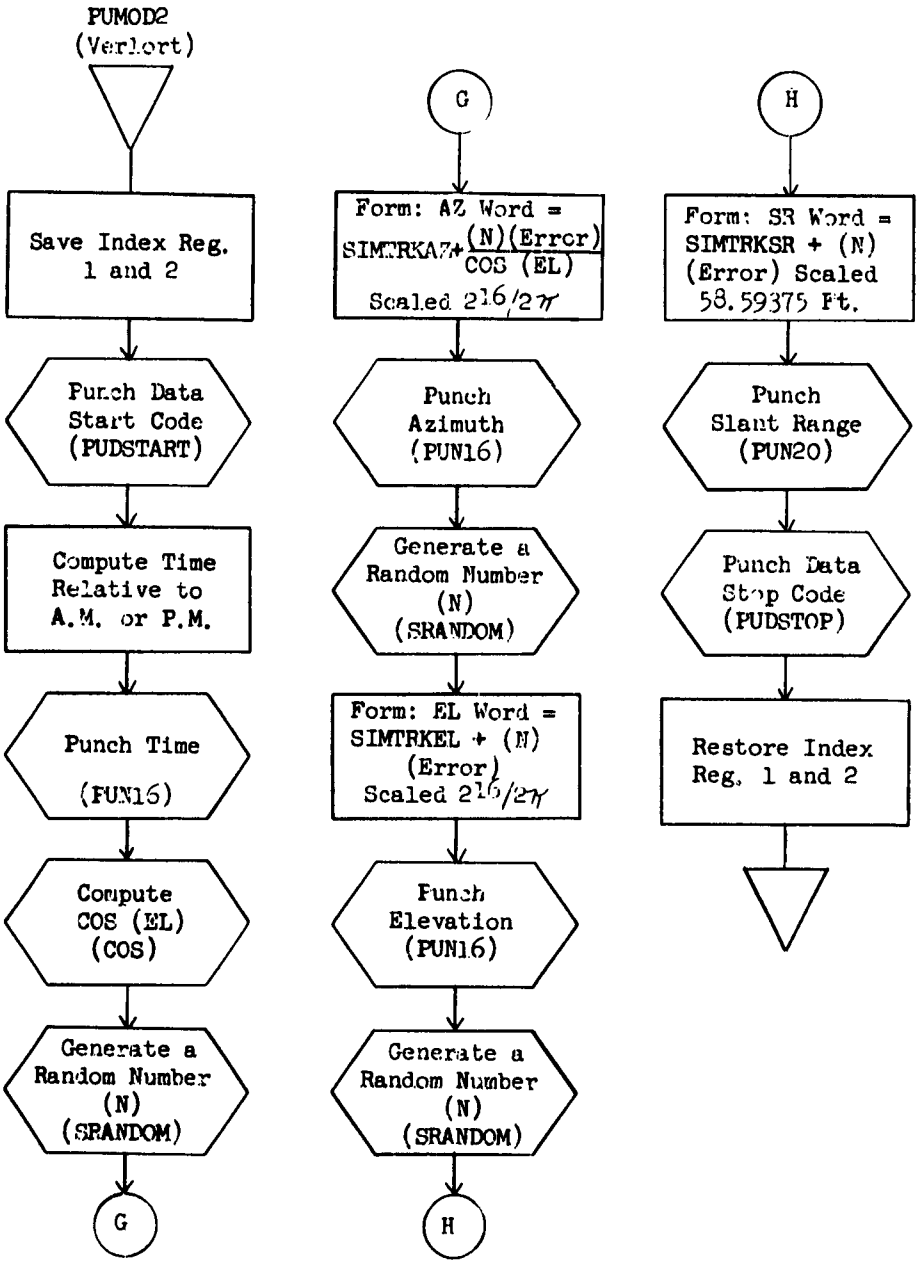
APPENDIX A

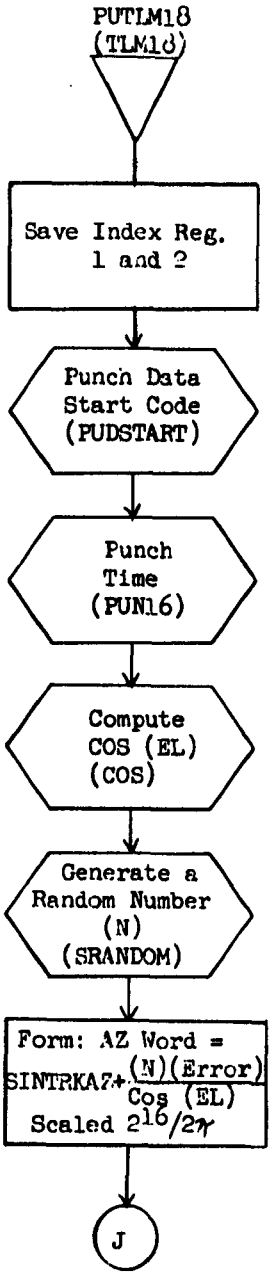

SRADTPE
Save Tau and Index Registers
Extract Vehicle Number from Calling Sequence
Extract Delta T from Calling Sequence
Extract Antenna Name From Calling Sequence
Extract Rev. Number from Calling Sequence
Extract Reset Tape Unit Number
Extract Station from Calling Sequence
a
a
Extract Print Option from Calling Sequence
Legal Antenna Specified
No
Error Printout
Yes
Yes
Delta Time Specified
No
Doppler or Ship PMR Antenna
No
Set Delta T Equal 4 sec
Yes
Set Delta T Equal 2 sec
Convert Delta to Floating Point FLOATBIN
Initialize Reference Pool and RESETBL RESET
b

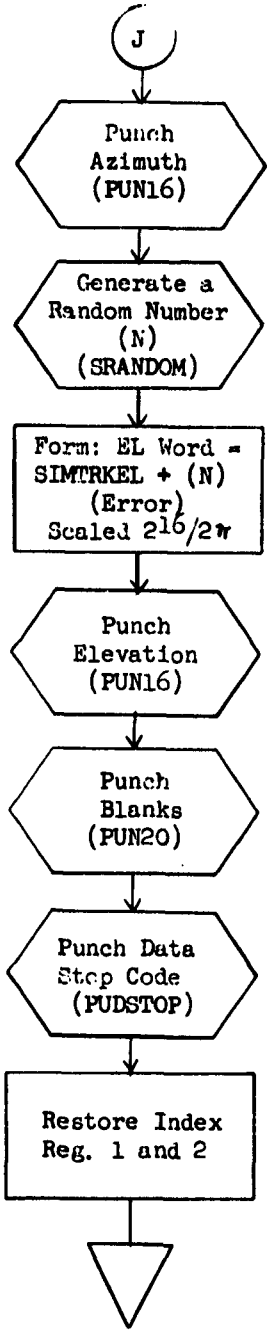

b
Initialize ST and Earth Constants SETUP
Augmentation Format Reset Tape
No
Yes
Search Acquisition Table for Revolution & Station Number
Extract Rise-Time and Duration. Set Tau to Rise-Time.
Compute Mid-Time and Set-Time
Check Ref. Pool for Station Coord. STCHK
Determine Rise Vector TTE
c
c
Convert to Inertial Rectangular PTR
Check Ref. Pool for Station Coord. STCHK
Determine Rise Vector and Rise,Mid,Set Time SACQTIME
Clear Stores for Azimuth, Elevation and Slant Range
Integrate to Nearest Multiple 4 sec for Beginning Point
Convert Inertial Rect. to Local Rect. Coordinates SIMCTIR
d

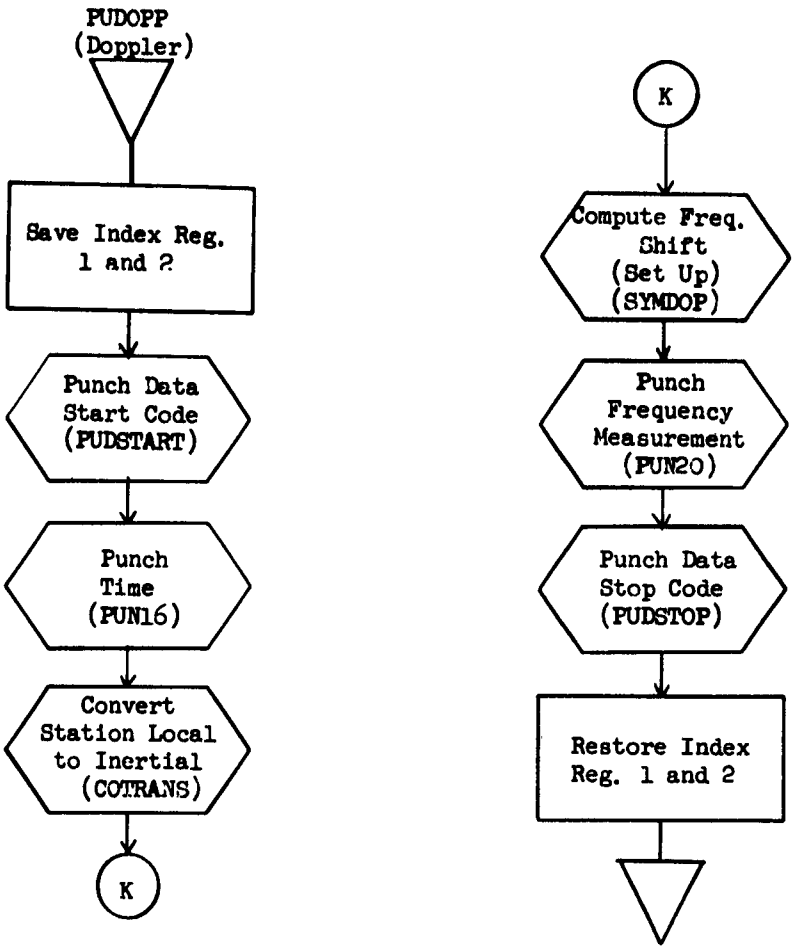

d
Convert Local Rect. to Local Polar Coordinates SIMCTRP
Convert Tau to System Time MACGUT
Set Up Address for Header Module from Antenna Type
Compute Length of Paper Tape Needed L=(Dur/6Δt + 3.75)ft.
Print On-line to Signal Operator SIMTAPE
Compute Total No. of Points Required for 1 Pass
e
e
Punch Paper tape Header and set up Module to Generate Data
f
SHIP ANG
PU-MOD2
PU-DOPP
PU-PMR
PU-TLM 18
PU-ANSPO
Is Off-line Data Output Listing Requested
Yes
List Tracking Data on Tape3 RADTPEPT
No
Integrate to Next Data Point for DT of 1 sec RKUTTA
Convert to Inertial Polar RTP
Time To Punch Out a Point
No
Yes
g

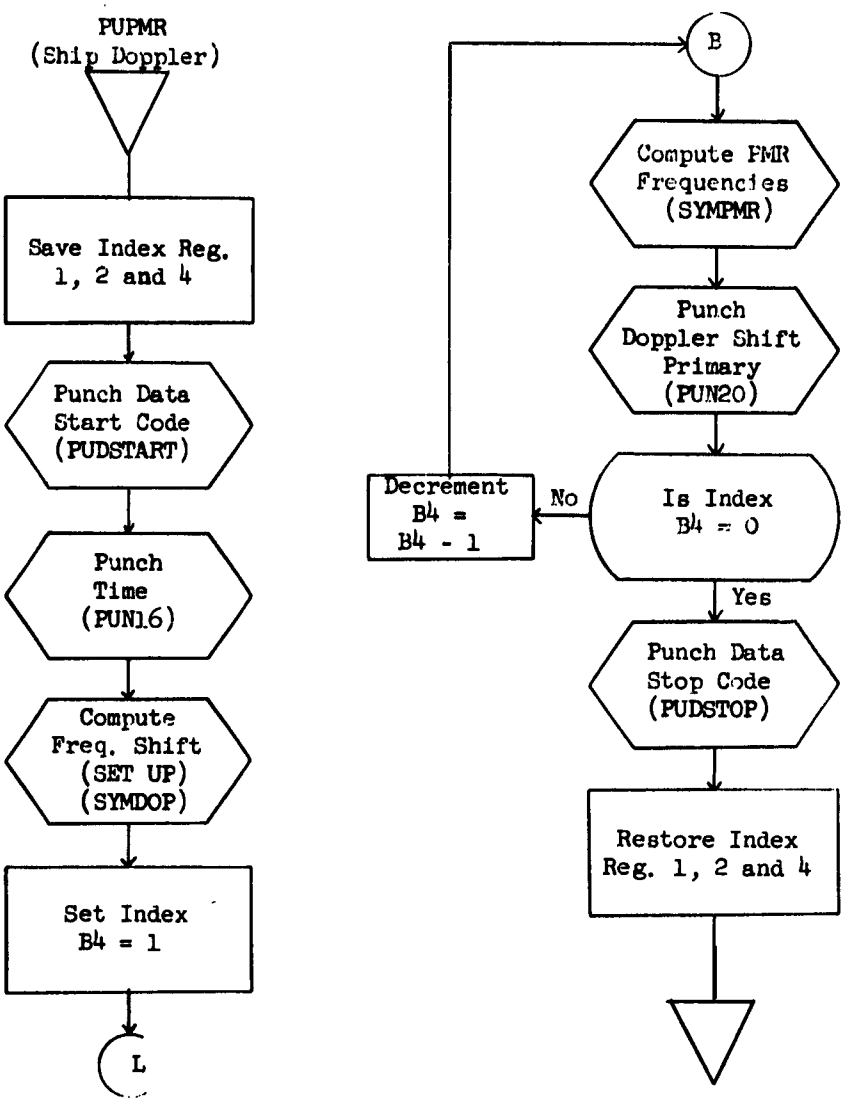

g
Convert Inertial Polar to Local Rectangular Coord. SIMCTIR
Convert Local Rect. to Local Polar Coord. SIMCTRP
Update Time Counters MACGUT
All Data Points Punched
No
Is Tau + Delta T greater than Set-Time
No
f
Yes
Yes
Punch End of Tape (Stop Codes) PUTSTOP
Print On-Line "No More Tracking Data"
Restore ST, TAU and Index Registers

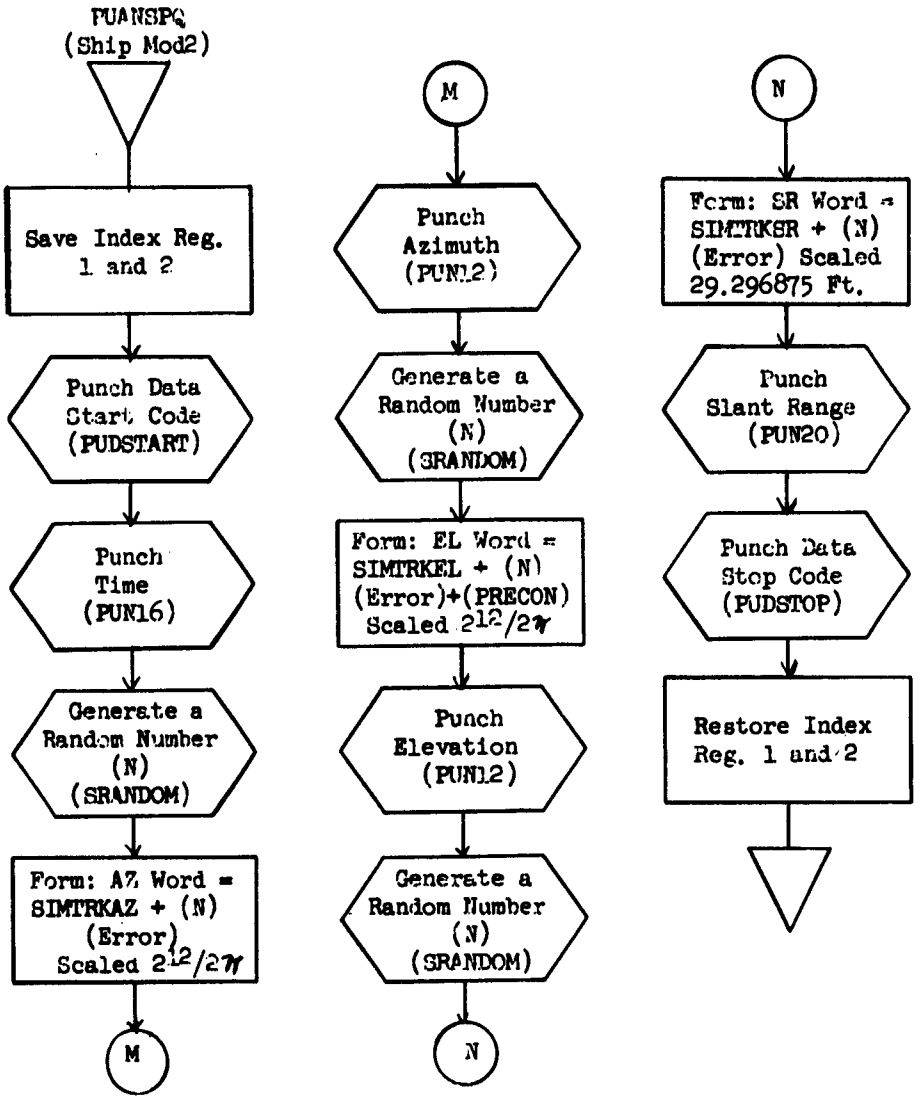

PUMOD2
(Verlort)
Save Index Reg. 1 and 2
Punch Data Start Code (PUDSTART)
Compute Time Relative to A.M. or P.M.
Punch Time (PUN16)
Compute COS (EL) (COS)
Generate a Random Number (N) (SRANDOM)
G
G
Form: AZ Word = SIMTRKAZ + (N)(Error) / COS (EL) Scaled 2^16/2π
Punch Azimuth (PUN16)
Generate a Random Number (N) (SRANDOM)
Form: EL Word = SIMTRKEL + (N) (Error) Scaled 2^16/2π
Punch Elevation (PUN16)
Generate a Random Number (N) (SRANDOM)
H
H
Form: SR Word = SIMTRKSR + (N) (Error) Scaled 58.59375 Ft.
Punch Slant Range (PUN20)
Punch Data Stop Code (PUDSTOP)
Restore Index Reg. 1 and 2

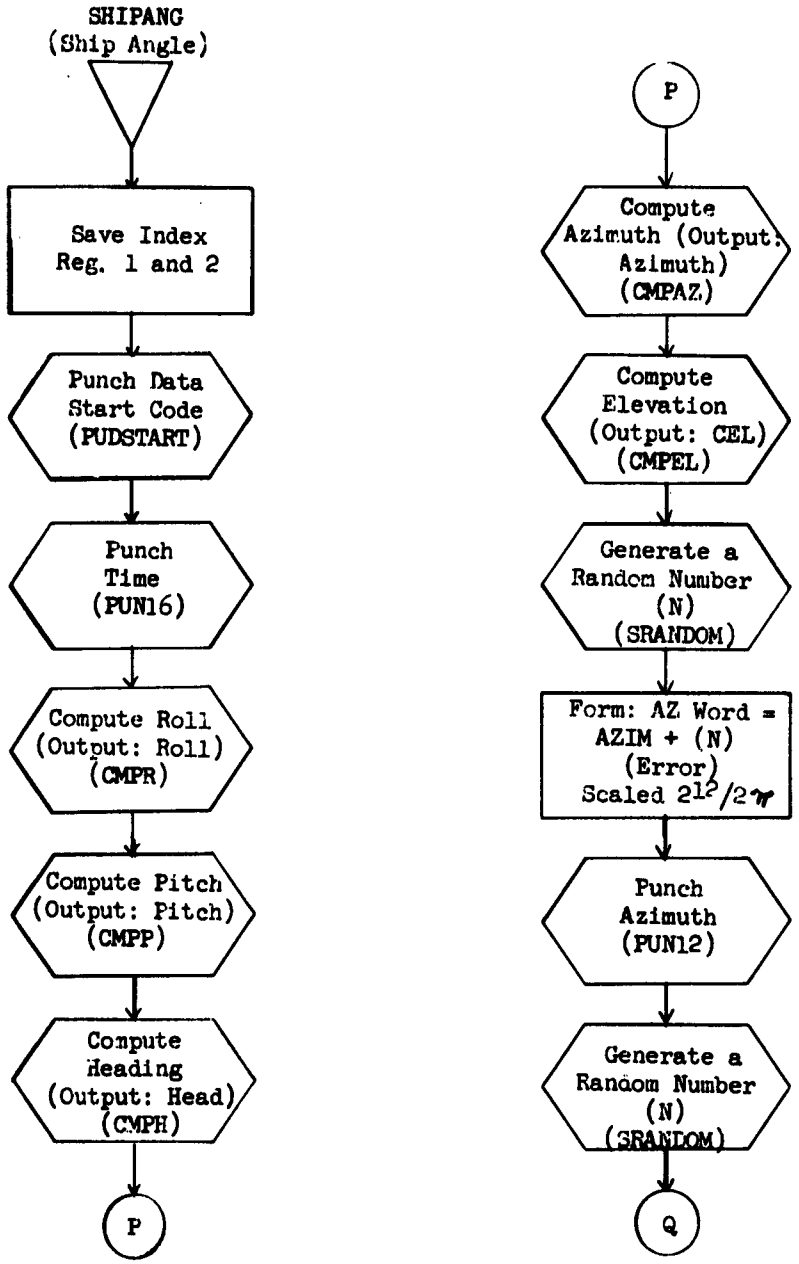

PUTLM18
(TLM18)
Save Index Reg. 1 and 2
Punch Data Start Code (PUDSTART)
Punch Time (PUN16)
Compute COS (EL) (COS)
Generate a Random Number (N) (SRANDOM)
Form: AZ Word = SINTRKAZ + (N)(Error) / Cos (EL) Scaled $2^{16}/2\pi$
J

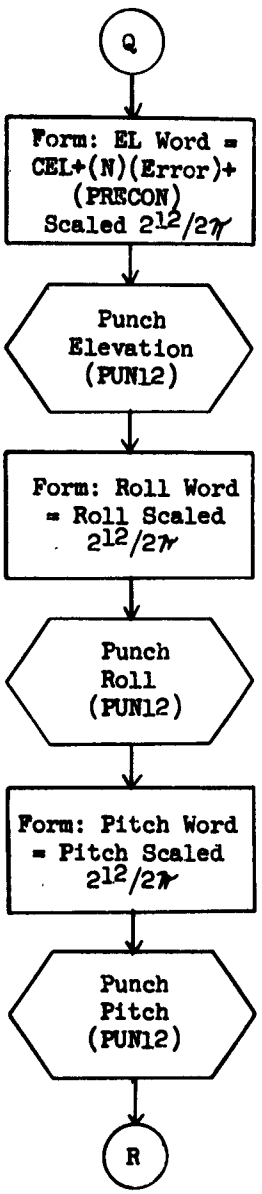

J
Punch Azimuth (PUN16)
Generate a Random Number (N) (SRANDOM)
Form: EL Word = SIMTRKEL + (N) (Error) Scaled $2^{16}/2\pi$
Punch Elevation (PUN16)
Punch Blanks (PUN20)
Punch Data Stop Code (PUDSTOP)
Restore Index Reg. 1 and 2

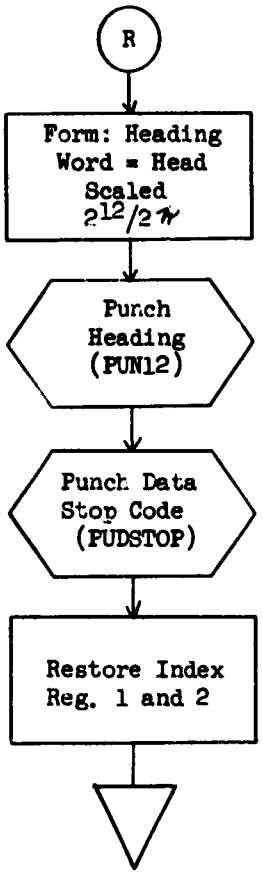

PUDOPP
(Doppler)
Save Index Reg.
1 and 2
Punch Data
Start Code
(PUDSTART)
Punch
Time
(PUN16)
Convert
Station Local
to Inertial
(COTRANS)
K
K
Compute Freq.
Shift
(Set Up)
(SYMDOP)
Punch
Frequency
Measurement
(PUN20)
Punch Data
Stop Code
(PUDSTOP)
Restore Index
Reg. 1 and 2


PUPMR
(Ship Doppler)
Save Index Reg. 1, 2 and 4
Punch Data Start Code (PUDSTART)
Punch Time (PUN16)
Compute Freq. Shift (SET UP) (SYMDOP)
Set Index B4 = 1
L
B
Compute PMR Frequencies (SYMPMR)
Punch Doppler Shift Primary (PUN20)
Is Index B4 = 0
No
Decrement B4 = B4 - 1
Yes
Punch Data Stop Code (PUDSTOP)
Restore Index Reg. 1, 2 and 4


PUANSPQ
(Ship Mod2)
Save Index Reg. 1 and 2
Punch Data Start Code (PUDSTART)
Punch Time (PUN16)
Generate a Random Number (N) (SRANDOM)
Form: AZ Word = SIMTRKAZ + (N) (Error) Scaled 2^12/2π
M
M
Punch Azimuth (PUN12)
Generate a Random Number (N) (SRANDOM)
Form: EL Word = SIMTRKEL + (N) (Error)+(PRECON) Scaled 2^12/2π
Punch Elevation (PUN12)
Generate a Random Number (N) (SRANDOM)
N
N
Form: SR Word = SIMTRKSR + (N) (Error) Scaled 29.296875 Ft.
Punch Slant Range (PUN20)
Punch Data Stop Code (PUDSTOP)
Restore Index Reg. 1 and 2


SHIPANG
(Ship Angle)
Save Index Reg. 1 and 2
Punch Data Start Code (PUDSTART)
Punch Time (PUN16)
Compute Roll (Output: Roll) (CMPR)
Compute Pitch (Output: Pitch) (CMPP)
Compute Heading (Output: Head) (CMPH)
P
P
Compute Azimuth (Output: Azimuth) (CMPAZ)
Compute Elevation (Output: CEL) (CMPEL)
Generate a Random Number (N) (SRANDOM)
Form: AZ Word = AZIM + (N) (Error) Scaled $2^{12}/2\pi$
Punch Azimuth (PUN12)
Generate a Random Number (N) (SRANDOM)
Q


Q
Form: EL Word = CEL+(N)(Error)+(PRECON) Scaled $2^{12}/2\pi$
Punch Elevation (PUN12)
Form: Roll Word = Roll Scaled $2^{12}/2\pi$
Punch Roll (PUN12)
Form: Pitch Word = Pitch Scaled $2^{12}/2\pi$
Punch Pitch (PUN12)
R


R
Form: Heading Word = Head Scaled $2^{12}/2\pi$
Punch Heading (PUN12)
Punch Data Stop Code (PUDSTOP)
Restore Index Reg. 1 and 2

APPENDIX B

```
*13  SIPSA  0  5
START
PUNCH          2404          TL18      8   5    1   1
PUNCH          2404          VELT      8   5    1   1
PUNCH          2404          DOPR      5   5    6   1
PUNCH          2404          ANQ2      8   5   20   1
PUNCH          2404          SPMR      8   5   20   1
PUNCH          2404          SHIP      8   5   20   1

*13 SRADTPE    2404    4     VELT      2   5    5   1
*13 SRADTPE    2404    2     TL18      8   5    1   1
*13 SRADTPE    2404    0     DOPR      5   5    6   1
*13 SRADTPE    2404    1     ANQ2      8   5   20   1
*13 SRADTPE    2404    2     SPMR      8   5   20   1
*13 SRADTPE    2404    4     SHIP      8   5   20   1
```

15 March 1963 TM-(L)-734/037/00

DISTRIBUTION
(EXTERNAL)

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(Contracting Agency)

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System Development Corporation,
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1604 SIMULATION PROGRAM DESCRIPTIONS
MILESTONE 11 TRACKING DATA PAPER TAPE
GENERATION ROUTINE (SRADTPE).
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23p., 3 refs.
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Unclassified report

DESCRIPTORS: Programming (Computers).
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~~Reports that~~ SRADTPE (Tracking Data Paper Tape Generation Routine) provides a simulation capability, which will produce tracking data on paper tape for unaugmented tracking stations. ~~Reports that this~~ The data ~~is~~ are intended to represent the actual data generated by various antennas during vehicle pass-over for a given station, vehicle, and revolution number. UNCLASSIFIED